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INCIDENCE AND IMPACT OF DAMAGE TO THE TIMBER RESOURCE IN NORTH CAROLINA

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ABSTRACT

Wood fiber loss and economic impact caused by destructive agents were determined for the North Carolina timber resource. Annual fiber loss is 85 million cubic feet of pole size and 344 million board feet of sawtimber size wood. At current timber values the loss amounts to 19.9 million dollars annually. Heart and butt rot diseases are causing the greatest cumulated volume loss in both conifers and hardwood. Most losses are occurring in the yellow pines, tupelo-black gum and the oaks. Similar procedures could be used in other states to determine certain impacts on the timber resource.

INTRODUCTION

The need for valid forest insect and disease incidence and impact data has long been recognized. Most of the past data and results were rough estimates, which before now were acceptable to forest land managers and administrators. In these times of record breaking insect and disease outbreaks, less money for suppression projects and changing public priorities, it is imperative that we know what effects forest pests and other damaging agents have on the forest ecosystem, and their economic and sociological impacts on the total forest resource. Very little accurate data and information have been developed to-date because of the complexity of the subject matter, lack of survey techniques to obtain good statistically sound data and the formidable job of collecting the data.

Impact may be defined in a number of ways. A broad definition which has acquired acceptability is "the cumulative net effect(s) of insects and diseases which result in modification of management activities for specified forest resource uses and values." Insects and diseases have both adverse and beneficial impacts on the forest ecosystem. Measurement of these impacts should yield the net effect as related to people, the economy and the environment. Some of these impacts would involve wood fiber loss including stand composition and stocking; economics and monetary considerations; soil fertility, stability and pollution; fire hazard; esthetic effects such as shade and natural beauty; and effects on habitats for other flora, birds, animals, insects and soil organisms.

To-date there have been three approaches used by the U.S. Forest Service's Forest Insect and Disease Management organization to collect impact data. These were 1) determining the effects of a specific pest on its host or hosts; 2) determining the effects of forest pest complexes on a forest stand, and; 3) determining the effects of a specific pest on its host

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or hosts and assigning an economic value to the net effect. There is another approach for gathering incidence and impact data which has possible merit. This method is related to obtaining forest survey data by the research forest experiment stations. The following paper outlines methods used and data obtained by the Southeastern Forest Experiment Station's Forest Survey Group. The writer has interpreted and applied additional methods to the Forest Survey damage incidence data to evaluate the wood fiber and economic impacts of damage causing agents. Data on damage incidence and impact, due to various damaging agents, including insects and diseases, were obtained in conjunction with the fourth evaluation of North Carolina's forest resources. These data were summarized and analyzed by a special companion computer program to the usual forest survey data processing system. Damage incidence data were not collected on the Pisgah and Nantahala National Forests.

The writer acknowledges the Southeastern Forest Experiment Station's Forest Survey Group especially Mr. Noel Cost, Dick Welch, Bob Cathey, and the survey foresters who took the data. In addition, appreciation is given to State and Private Forestry's Forest Insect and Disease specialists, especially Dr. William Sites and the North Carolina Division of Forest Resources who gave training sessions to the field survey crews. Special acknowledgement is given to Dr. Ellis Cowling, Department of Plant Pathology, North Carolina State University for developing with Forest Survey personnel the damage codes used in North Carolina, (Table 1). Cowling et. al (3) gives the insect and disease losses by regions in North Carolina.

METHODS

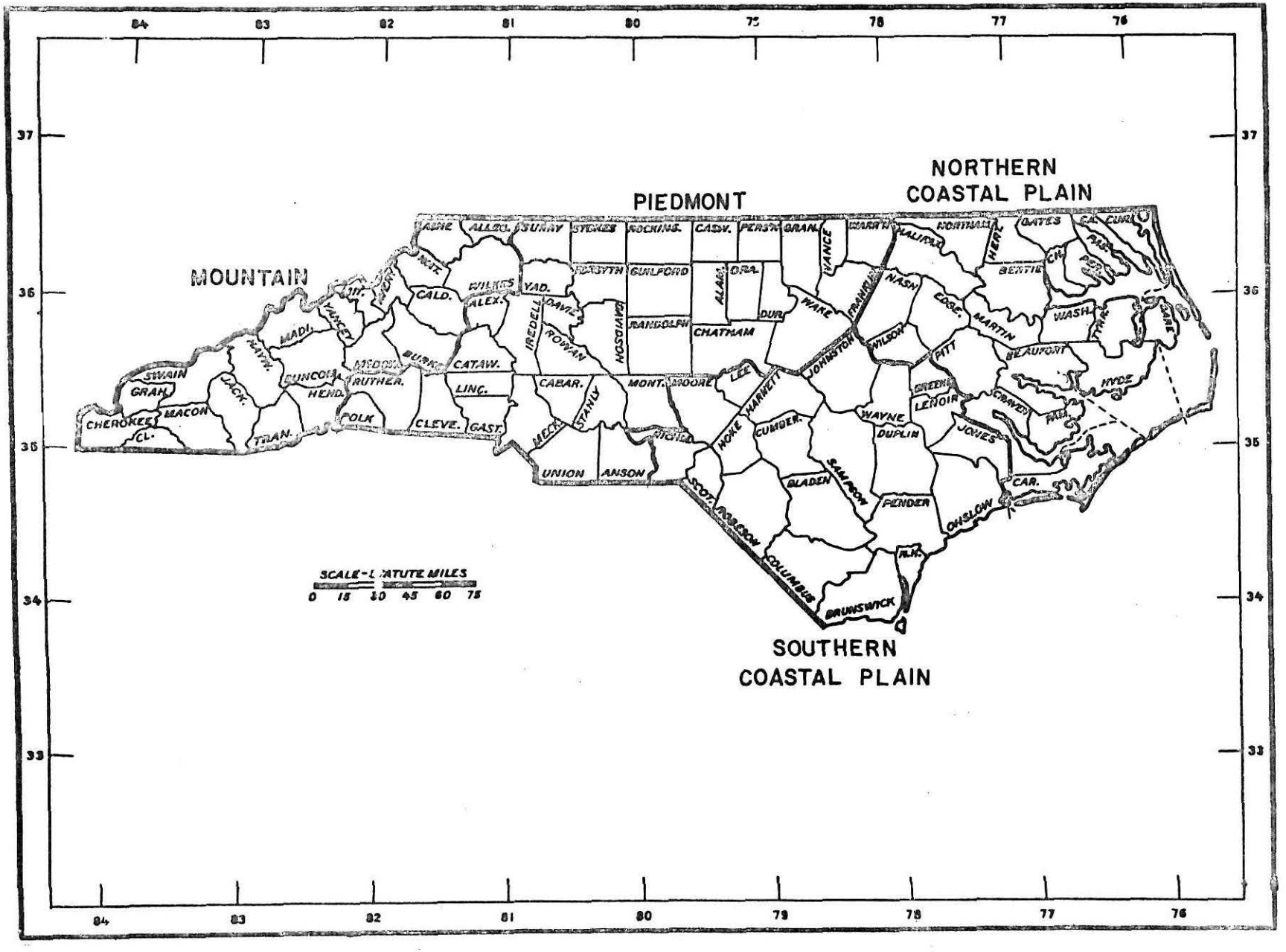
Forest Survey

The State of North Carolina was divided into four Forest Survey units: Southern Coastal Plain, Northern Coastal Plain, Piedmont and Mountain. The survey was started in November, 1972 and was completed in January, 1975, (1,2,4,5)

The survey method was essentially a sampling procedure designed to provide reliable statistics primarily for the state and survey units. Individual county statistics were presented so that any combination of counties could be added together until the total was large enough to meet the desired degree of reliability. Tree damage data was also taken in these survey units. The basic steps of the survey procedure were as follows:

Initial estimates of forest and nonforest areas were based on the classification of 108,579 sample clusters systematically spaced on the latest aerial photographs available. A subsample of 8,171 of the 16-point clusters was ground checked and a linear regression was fitted to the data to develop the relationship between the photo and ground classification of the subsample. This procedure provided a means for adjusting the initial estimates of area caused by changes in land use since the date of photography and for photo misclassifications.

NORTH CAROLINA SURVEY UNITS



Estimates of timber volume and classifications of forest types were based on measurements recorded at 4,882 ground sample locations systematically distributed throughout the commercial forest land within the state. A 10-point cluster of plots, measured with a basal area factor of 37.5 square feet per acre, was systematically spaced on an acre at each of these sample locations. Trees less than 5 inches dbh were tallied on a portion of the fixed-radius plots around the point centers.

Equations prepared from detailed measurements collected on standing trees at 303 sample locations in North Carolina, and similar measurements taken throughout the Southeast, were used to compute the volumes of individual tally trees. A mirror caliper and sectional aluminum poles were used to obtain the additional measurements on standing trees required to construct the volume equations.

Felled trees were measured at 91 active cutting operations to provide utilization factors for product and species groups and to supplement the standing tree-volume study. Estimates of growth, removals, and mortality were determined from the remeasurement of 4,895 permanent sample plots which were established in the third survey.

Ownership information was collected from local contacts, correspondence and public records. In those counties where the sample missed a particular ownership class, temporary sample plots were added and measured to describe the forest conditions within the ownership class.

All field data were sent to the Southeastern Forest Experiment Station for editing and were punched into cards and stored on magnetic tape for machine computing, sorting and tabulation. Final estimates were based on statistical summaries of the data.

Tree data were categorized as follows: saplings, 1.0 to 5.0 inches dbh; softwood poles 5.0 to 8.9 inches dbh; hardwood poles 5.0 to 10.9 inches dbh; softwood sawtimber 9.0 inches and above, hardwood sawtimber 11.0 inches and above.

Field training sessions in damage class identification were given by State and Private, Forest Insect and Disease Management Group, North Carolina Division of Forest Resources, and North Carolina State University, to thoroughly familiarize field survey foresters with the various insects, diseases, and damage to trees on the survey plots. The following damage descriptions were used to determine the insect, disease and other damage classes.

Table 1 gives the descriptions used to identify the causes of current damage to living trees on the sampled plots. The percent incidence and cull associated with the various damage classes were determined i.e., fusiform rust, annosus root rot, littleleaf, heart and butt rots, hardwood cankers, and other diseases. An average percent of all damage agents and cull associated with the damage was determined. Wood removals would have been markedly higher in some instances in the absence of these damaging agents. However, removals would not have been higher by the full amount of the percentages listed since percent incidence and

Table 1. Damage descriptions for the forest survey of North Carolina

Insect, Disease, Damage Class	Common host species	Symptoms
No damage	All species	No symptoms.
Insect	All pines	Loose bark, insect galleries in inner bark, exit holes.
Other diseases	All species	Damage due to diseases other than those indicated. For example, eastern gall rust, pitch canker, and red heart on pines.
Fusiform rust	Slash, loblolly, pitch, and pond pines.	Spindle-shaped galls on stem or within 12 inches of stem, canker on stem with sunken rotten center encircled by callus ridge, witches' broom, orange fruiting structures in spring.
Annosus root rot	Pines and red cedar	Diseased trees frequently occur in groups (centers) which usually contain dead or wind-thrown trees; diseased trees with thin, tufted crowns; wind-thrown trees exhibit stringy, white root rot; perennial shelf-like or flat conks against base of trees in litter or under roots of wind-thrown trees; conks are rubbery with tan to brown upper surface and white pore-bearing undersurface.
Littleleaf disease	Shortleaf pine	Affected trees occur in groups. Short yellow needles, reduced shoot growth on trees over 20 years old, large crops of undersized cones, usually occurs on heavy soils of poor internal drainage.
Blister rust	White pine	Stem canker often with yellow or brown blisters, usually above 3,000 feet elevation.

Insect, Disease Damage Class	Common host species	Symptoms
Hardwood cankers	All hardwoods	Dead sunken area on stem, frequently showing annual callus ridges.
Branch stubs	All species	Branch holes or stubs greater than 4" in diameter on stem.
Top breakage	All species	Broken stem greater than 4" in diameter.
Other basal defect	All species	Butt rot due to causes other than fire or logging damage (root rot, parent stump, frost seam, low stubs, butt bulge). Cause of cull is below dbh.
Fire	All species	Fire scar usually at base of stem, widespread in stand, usually on uphill side of slope charring on reburned stems.
Animal	All species	Beaver, bear, bird, rodent, rabbits, etc.
Weather	All species	Wind-thrown, lightning strikes ice and snow, hail.
Suppression and stagnation	All species	Overtopped tree with poor form.
Logging and related	All species	Logging scar on stem, callus ridges within 1-2 years after wounding, scattered in stand, no charring, limb breakage and/or stem scar near crown resulting from tree felling. Look for skid trails, stumps, etc.
Turpentining	All pines	Turpentining scars.
Form (damaging)	All species	Deformed due to unknown causes

Table 2. Area of commercial forest land by ownership, stand size class, and forest type group

OWNERSHIP	ACRES
Federal	1,347,179
State, County, Municipal	398,271
Private	17,799,385
All ownerships	19,544,835
STAND SIZE CLASS	
Sawtimber	8,211,834
Pole timber	6,292,195
Sapling-seedlings	4,552,997
Nonstocked areas	487,809
All Stand Sizes	19,544,835
FOREST TYPE GROUP	
White pine-hemlock	142,841
Spruce-fir	12,714
Longleaf-slash	554,974
Loblolly-shortleaf	6,194,059
Oak-pine	2,483,865
Oak-hickory	7,248,869
Oak-gum-cypress	2,237,447
Elm-ash-cottonwood	440,426
Maple-beech-birch	229,640
All type groups	19,544,835

cull associated damage does not imply total tree loss. Only a part of the associated cull loss volume would fail to qualify for some commercial purposes. This volume loss was determined by multiplying the percent incidence by the total wood volume in a tree species. This figure, in turn, was multiplied by the percent cull associated with the damaging agent to obtain wood fiber loss.

Economic impact was determined by multiplying the total wood fiber loss for each tree species by stumpage value per unit. Survey data were calculated back to an annual basis and economic impact was determined.

Mortality is also an important factor in wood fiber loss impact. This could not be determined for each damage class because it was impossible to attribute cause of death for each missing tree since the last survey made 10 years ago. It was possible, however, to determine total mortality for each tree species on each plot. By using total mortality by tree species it was possible to arrive at a total volume loss figure for poles and sawtimber by tree species.

RESULTS

North Carolina has approximately 19.5 million acres of commercial forest type. Over 14.5 million acres are sawtimber and pole size timber. The loblolly-shortleaf forest type comprises 6.2 million acres while the oak-pine type, oak-hickory type and oak-gum cypress type comprises 12.0 million acres. Table 2 gives the area of commercial forest land by ownership, stand size class and forest type group.

Tables 3 and 4 give the annual timber removals and wood volume loss to softwood and hardwood poles and sawtimber. Most losses occurred in the yellow pines and black-tupelo gum. The annual wood fiber loss was 85 million cubic feet of pole size and 344 million board feet of sawtimber size wood.

Tables 6 and 7 give the disease incidence, associated cull and accumulated volume loss to softwood and hardwood poles and sawtimber. Heart and butt rots caused the most volume loss in both softwoods and hardwoods. Disease associated losses were the largest in hardwoods. Cypress and loblolly pine showed the most loss in softwoods while black-tupelo gum and black locust showed the most loss in hardwoods. Volume loss resulting from fusiform rust was small and was negligible due to annosus root rot and littleleaf disease.

Table 5 shows the economic impact of damage on the timber resource. Representative average stumpage prices for the 1972-75 period as furnished by Mr. Alex Dowdell, forest utilization specialist of the North Carolina Department of Natural and Economic Resources was $60 and $30 per thousand for pine and hardwood sawtimber and other products averaged $6 and $3 per cord.

Table 3. Annual timber removals and wood volume loss to softwood poles and sawtimber

Species	Annual Timber Removals		Volume Loss Due To Mortality		Accumulated Cull	
	Poles	Sawtimber	Poles	Sawtimber	Poles	Sawtimber
	M ft.^{3}	MBF	M ft.^{3}	MBF	M ft.^{3}	MBF
Yellow pines	59,688	1,593,003	43,985	134,275	241	323
Eastern white pine	420	46,291	423	4,915	9	26
Spruce & fir	--	--	204	--	--	--
Cypress	372	34,488	276	1,759	69	733
Other eastern softwood	2,441	11,651	434	1,902	64	111
TOTAL SOFTWOODS	62,921	1,685,433	45,322	142,851	383	1,193

Yellow pines---------- Loblolly, slash, longleaf, shortleaf, virginia, pitch, and pond

Cypress---------- Bald and pond

Other eastern softwoods - Cedar and hemlock

Table 4. Annual timber removals and wood volume loss to hardwood poles and sawtimber

Species	Annual Timber Removals		Volume Loss Due To Mortality		Volume Loss Due To Accumulated Cull	
	Poles	Sawtimber	Poles	Sawtimber	Poles	Sawtimber
	M ft.^{3}	MBF	M ft.^{3}	MBF	M ft.^{3}	MBF
Select white & red oaks	16,455	190,435	972	21,203	333	1,231
Other white & red oaks	18,023	232,514	7,127	44,221	1,579	3,042
Hickory	3,997	40,370	585	17,417	570	880
Yellow birch	14	3,382	--	--	35	142
Sweet Gum	10,631	150,367	1,405	23,788	2,221	2,141
Ash, walnut, & cherry	2,834	25,396	2,876	6,983	1,222	1,316
Yellow poplar	6,399	150,688	1,048	12,557	819	607
Tupelo, blackgum	6,432	146,133	1,652	14,427	4,920	13,624
Bay, magnolia	1,487	414	98	248	742	833
Other eastern hardwoods	15,353	105,246	8,906	33,431	3,881	2,010
Total Hardwoods	81,625	1,044,945	24,669	174,275	15,100	25,826
TOTAL ALL SPECIES	144,174	2,730,378	69,991	317,126	15,483	27,019

Select white & red oaks - white, swamp chestnut, cherrybark, northern red

Other white & red oaks - chestnut, post, water, southern red, scarlet, black

Table 5. Economic impact of damage on timber resource

	Wood Fiber Loss	Stumpage Value Per Unit	Dollars Lost
Softwood			
Sawtimber (MBF)	144,044	$60/M	$ 8,642,640
Poles (M ft.^{3})	45,705	6/cord	3,638,400
Hardwood			
Sawtimber (MBF)	200,101	$30/M	6,003,030
Poles (M ft.^{3})	39,769	3/cord	1,590,759
Total All Species			
Sawtimber (MBF)	344,145		14,645,670
Poles (M ft.^{3})	85,474		5,229,159
GRAND TOTAL			$19,874,829

1 ft.^{3} = 4.5 BF

1 cord = 75 ft.^{3}

Table 6. Disease incidence, associated cull and accumulated volume loss in conifers.

Disease and Host	No. of Trees (Millions)	Incidence Percent Trees Infected Saplings (Percent)	Poles (Percent)	Sawtimber (Percent)	Associated Cull Percent Trees Affected Poles (Percent)	Sawtimber (Percent)	Accumulated Volume Loss Poles (M ft.3)	Sawtimber (MBF)
FUSIFORM RUST								
Loblolly	1,527	7.66	5.23	2.71	0.30	1.23	184	286
Pond	434	3.01	4.36	7.87	0.77	0.77	123	89
Virginia	681	0.00	0.30	0.20	0.00	5.00	0	12
Slash	38	16.65	19.38	0.00	0.00	0.00	0	0
ANNOSUS ROOT ROT								
Loblolly	1,527	0.03	0.10	0.08	0.00	0.00	0	0
LITTLELEAF DISEASE								
Shortleaf	507	0.22	0.70	0.86	0.00	0.00	0	0
HEART & BUTT ROTS								
Cypress	38	0.00	4.12	13.40	12.00	21.60	205	1,886
Loblolly	1,527	0.58	1.54	2.24	4.49	5.11	809	983
Pond	434	2.79	4.89	2.32	4.97	5.73	887	196
White	103	0.00	1.28	1.90	7.00	14.83	69	217
Virginia	681	0.41	1.85	2.88	2.62	7.92	293	266
Shortleaf	507	0.77	1.04	1.16	1.00	6.83	67	172
Longleaf	93	3.15	2.33	3.05	1.67	4.12	48	92
OTHER DISEASES								
Pond	434	0.39	2.21	4.11	0.67	1.32	54	80
Loblolly	1,527	0.25	0.12	0.55	0.00	1.85	0	87
Virginia	681	2.50	5.21	5.31	0.24	0.00	76	0
Shortleaf	507	0.31	0.38	0.57	0.00	3.61	0	45
White	103	0.00	0.00	0.68	0.00	10.00	0	52

Table 7. Disease incidence, associated cull and accumulated volume loss in hardwoods.

Disease and Host	No. of Trees	Incidence: Percent Trees Infected			Associated Cull: Percent Trees Affected		Accumulated Volume Loss	
		Saplings	Poles	Sawtimber	Poles	Sawtimber	Poles	Sawtimber
	(Millions)	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)	(M. ft.3)	(MBF)
HARDWOOD CANKERS								
Black & Tupelo Gum	1,011	0.12	1.32	1.56	14.08	16.87	1,307	7,328
Black Locust	68	1.13	6.77	7.74	32.69	20.75	2,691	492
Red Maple	2,063	0.06	0.65	1.38	5.24	12.58	3	1,170
Other White & Red Oaks	1,299	0.30	0.59	0.88	3.27	8.03	201	250
Select White & Red Oaks	636	0.00	0.69	0.50	2.08	7.29	110	134
Hickory	367	0.30	0.36	0.84	2.50	8.00	28	89
Ash	357	0.00	0.65	0.76	4.29	10.83	52	40
Black Walnut	10	0.00	9.47	1.86	3.33	10.00	49	8
Sweet Gum	1,501	0.11	0.24	0.45	0.00	10.31	0	96
HEART & BUTT ROTS								
Black & Tupelo Gum	1,011	0.31	12.58	29.33	14.33	18.69	12,677	15,264
Other White & Red Oaks	1,299	0.30	3.18	6.13	17.67	21.86	5,840	4,743
Black Locust	68	0.00	8.15	26.53	30.88	21.32	3,060	1,734
Ash	357	0.56	8.08	23.28	17.53	20.85	2,659	2,346
Select White & Red Oaks	636	0.00	1.12	2.03	16.92	19.62	1,454	1,467
Sycamore	12	0.00	11.83	9.14	5.00	23.61	247	1,455
Black Cherry	120	0.00	10.17	9.24	11.61	26.25	562	146
Red Maple	2,063	0.92	12.92	29.29	18.12	24.58	20	884
OTHER DISEASES								
Black Cherry	120	0.79	1.15	0.00	40.00	0.00	219	0
Black Locust	68	0.00	1.54	4.04	0.83	12.78	16	158
Other White & Red Oaks	1,299	0.21	0.13	1.67	0.27	2.50	5	24
Sweet Gum	1,501	0.06	0.03	0.02	0.00	40.00	0	17
Select White & Red Oaks	636	0.00	0.10	0.17	0.00	2.50	0	16

The value of softwoods and hardwoods lost was $12.3 and $7.6 million annually. The total annual loss was $19.9 million.

There were many other impacts on the timber resource which were not measured i.e., wildlife habitat, water, soil, environment, aesthetic, etc., nor were the costs of harvesting, transporting and processing deformed logs that yield low product recovery. Added to the costs and fiber losses resulting from insects and diseases, this represents an annual economic impact of additional dollars irretrievably lost.

DISCUSSION

Past estimates of volume and financial loss figures attributed to insects, diseases and other damage causing agents appear to be inconsistent to what is actually occurring in North Carolina. Estimates of timber losses due to disease based on the Timber Resources Review made in 1952 were $9.7 million for growing stock and $9.3 million for sawtimber. This included mortality and other quantitative losses, but not loss in quality. Losses from the current timber resource survey was $19.9 million. The estimated income from forest products in North Carolina for 1975 was $150 million.

The use of Forest Timber Resource data has merit in the determination of volume and economic loss impact. The data obtained, while it is not complete from the true impact definition, is based on a solid statistical sampling method and it has a broad data base with millions of trees. The three components for measuring volume loss impact are volume foregone, mortality, quality and physical growth loss. The data presented here have the first and second components. However, to obtain the third component permanent evaluation plots would need to be established with data taken annually or biennially. These plots would have to be evaluated over the expected rotation of the forest types in order to determine what destructive damaging agents were actually causing tree mortality. Most forest land managers cannot afford to wait that long. The Forest Timber Resource data base with its damage assessment program should give them an estimate on which to make better forest management decisions.

Similar resource impact data has been obtained in Virginia. The South Carolina survey will begin this spring and should be completed in 2 years. When the printouts of the incidence and cull data become available, a report such as this one should be written. A summary report of data from all states in the Southeast should be written when they have been completed.

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